

materials, including conventional silicon chip materials, may be used to construct some or all portions of fluid paths **20, 30**.

[0071] Convection controller **50** may be constructed in any manner and of any material(s) that allow convection controller **50** to inhibit the convection of fluid between fluid paths **20, 30** while allowing at least some diffusion between fluid paths **20, 30**. For example, convection controller **50** may reduce or completely eliminate convection between fluid paths **20, 30** while permitting fluids within the paths, or materials contained within the fluids, to diffuse between fluid paths **20, 30**.

[0072] Convection controller **50** may inhibit convection in any manner that reduces convection to a level required for a particular embodiment and need not necessarily eliminate convection. For example, convection controller **50** may provide a physical barrier, such as a wall or membrane preventing convection across contact region **40**. Similarly, convection controller **50** may allow diffusion in any manner that allows a desired level of diffusion for a particular embodiment and need not be open to diffusion by all materials. For example, convection controller **50** may include pores or may be constructed of a material, such as a gel, through which material may diffuse. Combinations are also possible, for example, in some embodiments, gels could be included within pores. Convection controller **50** may be selective, allowing only certain sizes or types of materials to diffuse through it.

[0073] In one embodiment, convection controller **50** includes a membrane capable of inhibiting convection while allowing diffusion. Where convection controller **50** includes a membrane, the membrane may have sufficient strength and durability to inhibit convection to a desired level. For example, the membrane may be sufficiently strong to withstand a pressure difference across the membrane where such a pressure difference may be present in microfluidic system **10**. The membrane may also have sufficient permeability to permit material to diffuse through it. For example, the membrane may be porous. Where the membrane is porous, the size of the pores may be large enough to allow diffusion of desired materials, but small enough to inhibit convection or diffusion of undesired materials. For example, in some embodiments, where it is desired to diffuse relatively large materials, such as cells, pores may be as large as the materials, or slightly larger. In other embodiments where it is desired to screen all but the smallest materials, pores may be as small as the smallest materials to be screened. For example, reverse osmosis, nanofiltration or ultrafiltration membranes may be used. In one embodiment, 0.1 micrometer pores have been demonstrated to allow a desired level of diffusion.

[0074] The effectiveness of using pores in a membrane to inhibit diffusion may be demonstrated as follows. The pressure drop for convection through a channel is proportional to the fourth power of the diameter of the channel. When a $100 \times 100 \mu\text{m}^2$ channel is replaced by 10^4 membrane pores of the same length and with the cross-sectional area of $1 \mu\text{m}^2$ each, at the same pressure gradient, the volumetric flow rate through individual pores is lower than the flow rate through the channel by a factor of 10^8 . The total convection through 10^4 pores is therefore reduced by a factor of 10^4 .

The diffusion is not affected by this replacement because the total cross-sectional area of the initial channel and of the pores is the same.

[0075] In some embodiments, it may be desired to screen particles based on properties other than size. For example, particles could be screened based on affinity or repulsion for a particular material, their partition coefficient, or their ability to form covalent bonds or otherwise chemically react with a particular material. In particular embodiments, the membrane may be charged to repel materials having a similar charge and attract materials having an opposite charge, may be hydrophobic or hydrophilic, or may have a bioaffinity for particular materials.

[0076] In some embodiments, convection controller **50** may trap materials from two streams. For example, where convection controller **50** is a gel or the like, materials and the products of the materials' interaction may be trapped in the gel. The fluid may then be removed from the streams and other fluids, such as a fluid containing a material capable of identifying the interaction product. Such a technique may be suitable for performing immunoprecipitations. Alternatively, the flow paths may be sealed for further interaction or archiving. As described in greater detail below, it is also possible to use this technique such that only one fluid path is required and the convection controller may be eliminated. For example, in some embodiments, two fluid paths may be placed, one after another, in communication with a gel that could have functioned as a convection controller or other immobilizer. In certain embodiments, gel convection controllers may be flowed into position between two fluid paths through a third fluid path positioned between them.

[0077] Convection controller **50** may be sized and configured in any manner that allows it to inhibit convection and permit diffusion, as desired. For example, convection controller **50** may be sized and configured to cover all of contact region **40**. Where convection controller **50** is a membrane it may be generally planar and may be thick enough to provide desired strength and durability to the membrane and thin enough to allow sufficient diffusion. The thickness meeting this criteria may vary with the material from which the membrane is constructed. In some embodiments, a single convection controller **50** may be used at multiple contact regions **40**. For example, convection controller **50** may be large enough to span several contact regions **40**. In one embodiment, convection controller **50** is a membrane between two layers of material including fluid paths and covers all of the fluid contact regions **40** between the fluid paths, as illustrated in FIGS. 3 and 4.

[0078] In some embodiments, convection controller **50** may be desired to provide a relatively large region for interaction between materials from fluid paths **20, 30**. In addition to the possibility of increasing the size of contact region **40**, for example by modifying the configuration of fluid paths **20, 30** as described previously, it may be desired to increase the depth of convection controller **50**. For example, convection controller **50** may be made thicker to allow more material to be diffused within convection controller **50**. In one embodiment, convection controller **50** may include internal voids wherein interactions between materials from fluid paths **20, 30** may occur and be observed. In another embodiment, convection controller **50** may include two or more surfaces, such as membranes, with a space or